Experiment of Sea Breeze Convection, Aerosols, Precipitation and Environment (ESCAPE)

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ESCAPE Science Team

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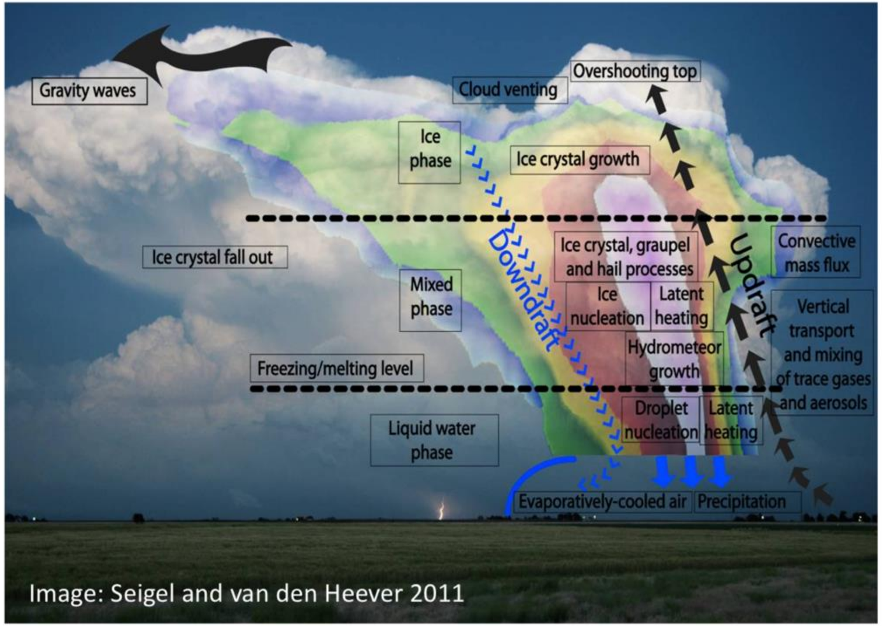
Science objectives

<u>Convective storms</u> *transport water vapor and condensate. Life on Earth is fundamentally linked to this transport.*

Study the microphysical and dynamical properties of isolated convective clouds through out their lifecycle

Quantify <u>environmental</u> thermodynamic and kinematic controls on convective lifecycle properties under different <u>aerosol</u> conditions



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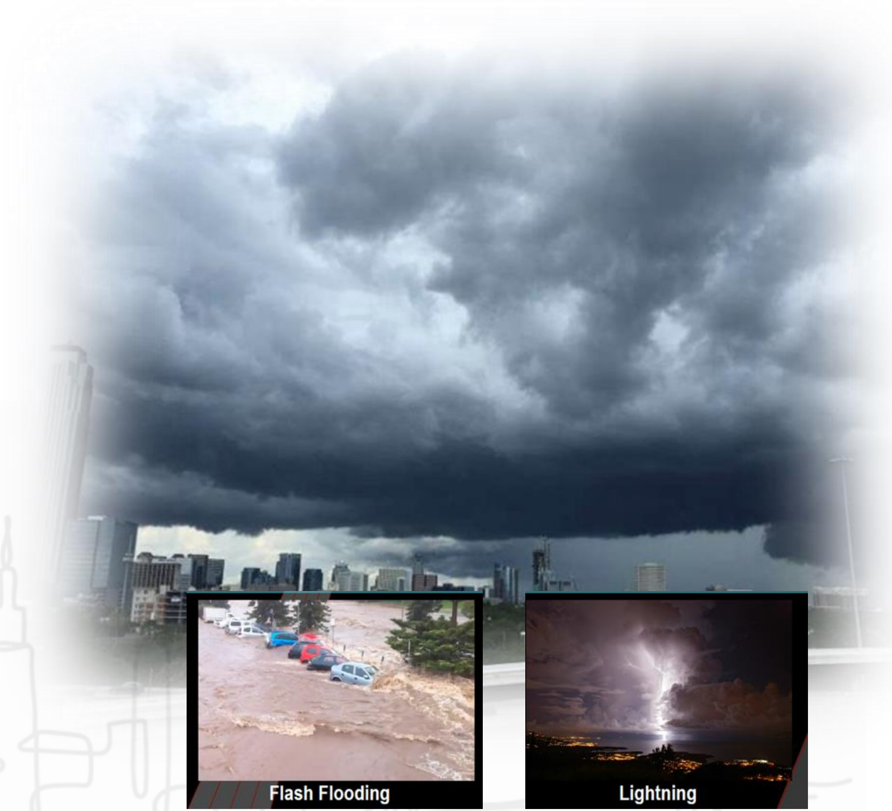
Why Houston

Natural laboratory for the generation of isolated convective cells under onshore (sea breeze) flow

- ❑ *Statistics*
- ❑ *Limited synoptic scale influences*
- ❑ *Existing infrastructure*

Large contrasts and interfaces

- ❑ *Aerosol conditions*
- ❑ *Land – Ocean (coastal) interface*
- ❑ *Human – Environment interface*



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ESCAPE challenges – timeline

Dec 2019:	Facility request (King air, DOW's)
Feb 2020:	Science proposal submitted
May 2020:	Feedback to OFAP May 2020
June 2020:	Funding decision June 2020
July 2020:	Aircraft facility change
July 2020:	Replace DOW's with other radars
Fall 2020:	Plan ESCAPE for 2021
April 2021:	NCAR C-130 unavailable (service)
May 2021:	Postpone to 2022 with C-130
Fall 2021:	Replace NOXP with PX-1000
Jan 2022:	NCAR C-130 unavailable
April 2022:	Sign contract with NRC Convair-580

ESCAPE field campaign

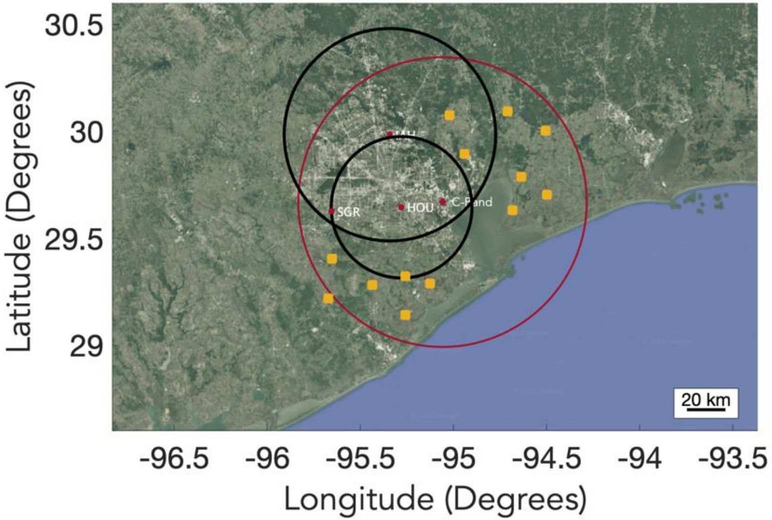
Airborne campaign: May 30th – June 19/26
Surface observatories: May 30th – June 30th
C-band radar: May 30th – August 31st

First day of flights: Monday, May 30th
Last day of flights: June 19 or June 26

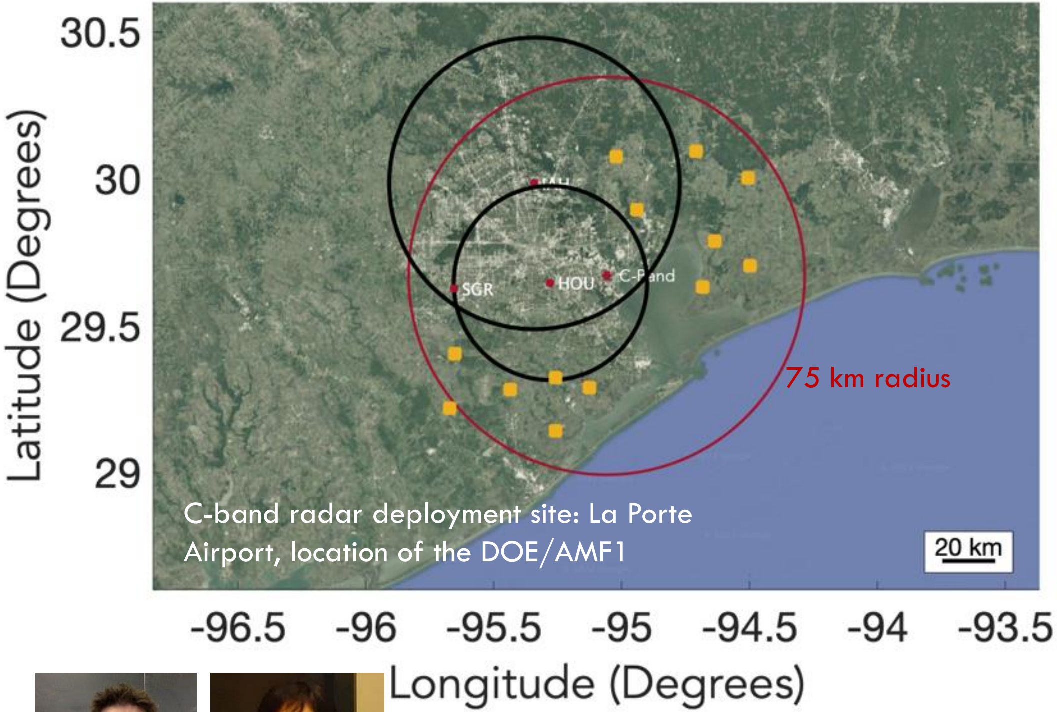
SPEC Learjet 35A:
- 32 hours of research flights
- ~ 8 flights

NRC Convair 580:
- 60 hours of research flights
- ~14 flights

Airport: Sugar Land Regional Airport



Dual-polarization C-band radar (CSU, Chivo)



Operational mode: Surveillance and cell tracking

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Oklahoma U. Mobile X-band radars

Parameter	Value
Center frequency	9.73 GHz ±20 MHz
Transmit power	20-kW peak, 200-W avg
Transmit pulse width	0.1–40 us
Transmit waveform	RF pulse, linear or custom chirp
Transmit polarization	Equal power V and H
PRT	Uniform or staggered
Antenna type	Dual-linear polarized parabolic reflector
Antenna diameter	2.4 m
Antenna beamwidth	1.0° half power
Antenna gain	44.5 dB
First sidelobe	27 dB
Pedestal type	Elevation over azimuth
Pedestal scan rate	180° s^{-1} in azimuth 36° s^{-1} in elevation

General	
Operating frequency	9550 MHz
Typical PRF	2000 Hz
Typical observation range	60 km
Antenna (Seavey Antenna C0824-820)	
Antenna gain	38.5 dBi
Diameter	1.2 m
3-dB beamwidth	1.8°
Polarimetric isolation	26 dB
Polarization	dual linear

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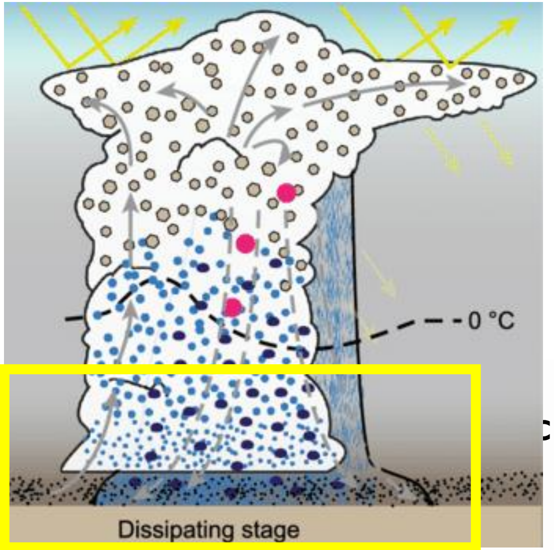
Stony Brook University SKYLER

Table I
Technical characteristics of the SKYLER I and II systems

Parameter	Range
Operational Frequency Band	9.0-9.6 GHz
Tx Power	< 250 W
Antenna size	~1 m x 1m
Antenna beamwidth	~ 2º x 2º
Maximum Duty Cycle	25%
Pulse Repetition Frequency	Selectable, typical 1.2 – 4.0 kHz
Pulse Width	Selectable, typical 1 – 55 µs
Waveform Pulse Modulation	CW, LFM, NLFM
Tx/Rx Polarization Modes	HH, HV, VV, VH
Angular Coverage	±45°azimuth by ±15°elevation
Instrumented Range	40 km

Dual-polarization X-band Phased-Array Radar

Characterize the cold pool thermodynamical structure using the scanning Doppler lidar, soundings, profiling radar/lidar, disdrometer and surface meteorology



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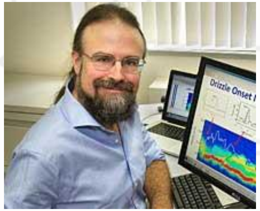

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Radiosondes and Swarmsondes

200 DFM-09 Radiosondes
5 per IOP x 2 mobile trucks
20 IOP days

A Swarmsonde is released with two balloons attached to the sonde

Specifications	
Balloon size	8 gram, 20 liters of helium. 2 balloons needed per sonde.
Payload	12 grams
Sondes per radio frequency	16 (can be customized)
Radio transmission range	> 15 km from air-borne sonde
Sonde recovery	Transmitted GPS location. Buzzer. Strong LED. (Option)
Measurement period	~1 hour (can be customized)
Parameter	**Measurement interval**
Wind	2 sec
Position	6 sec
Geopotential altitude	12 sec
Temperature	2 sec
Humidity	2 sec
Pressure	6 sec

32/IOP x 10 IOPs

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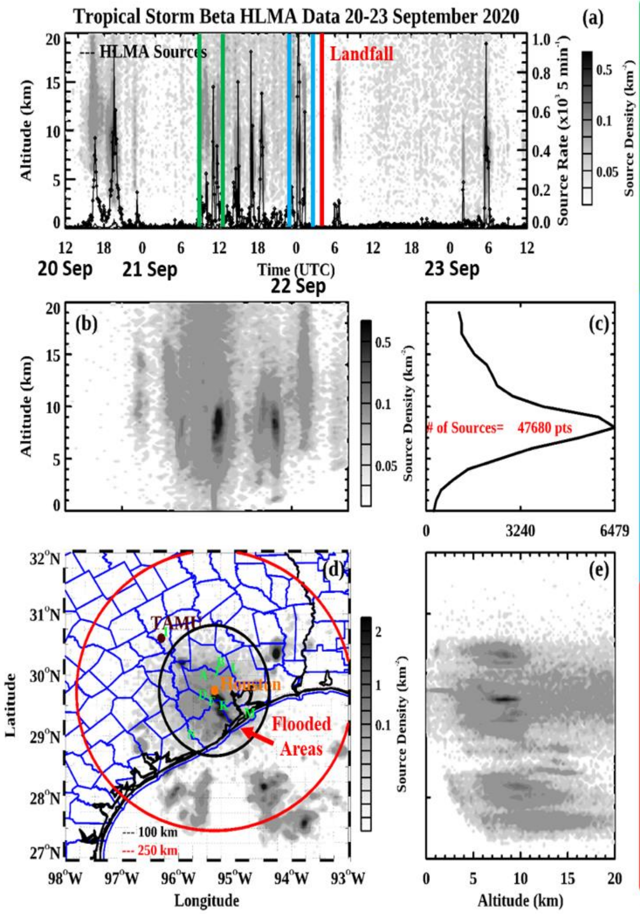
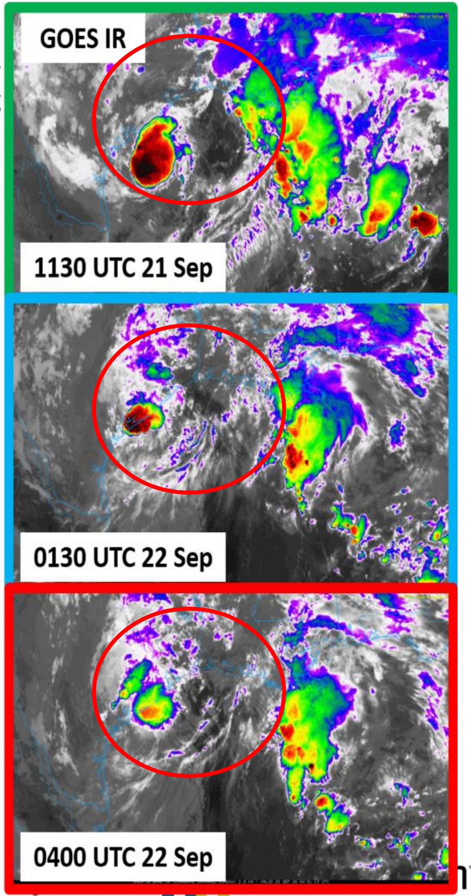
Houston Lightning Mapping Array (HLMA)

The Houston Lightning Mapping Array (HLMA) was established in April 2012. It is currently a network of 10 time-of-arrival lightning sensors centered on the Houston Metropolitan area that provide 3D lightning information to a range of 100 km and 2D mapping and acceptable flash counts within a 250 km radius of the network center.

In preparation for ESCAPE, the Bay City Airport Sensor (N) has been added and all other stations (A, B, D, F, I, J, K, L, and M) have been refreshed to ensure quality 3D mapping and mapping of small flashes over expected IOP domain.





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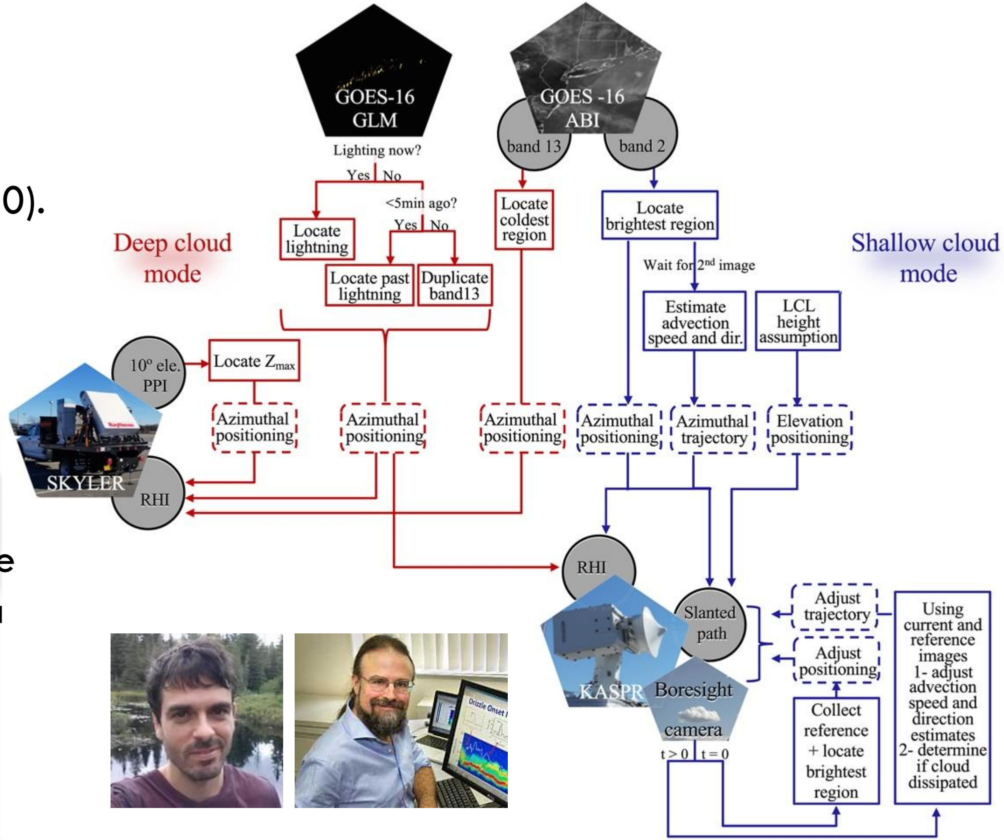
(Credit COD Weather for GOES IR imagery)

Multisensor Agile Adaptive Sampling (MAAS)

MAAS is a **new radar sampling paradigm** that relies on observations from non-radar and radar sources to steer radars (lidars) (*Kollias et al.*, 2020).

It benefits from each sensor's unique sensitivity to different parts of the atmospheric system.

Greater awareness of the atmospheric state is achieved, and rapid sequences of high-quality targeted radar scans can be collected without the need for a radar network, but instead by using a diversity of sensors.



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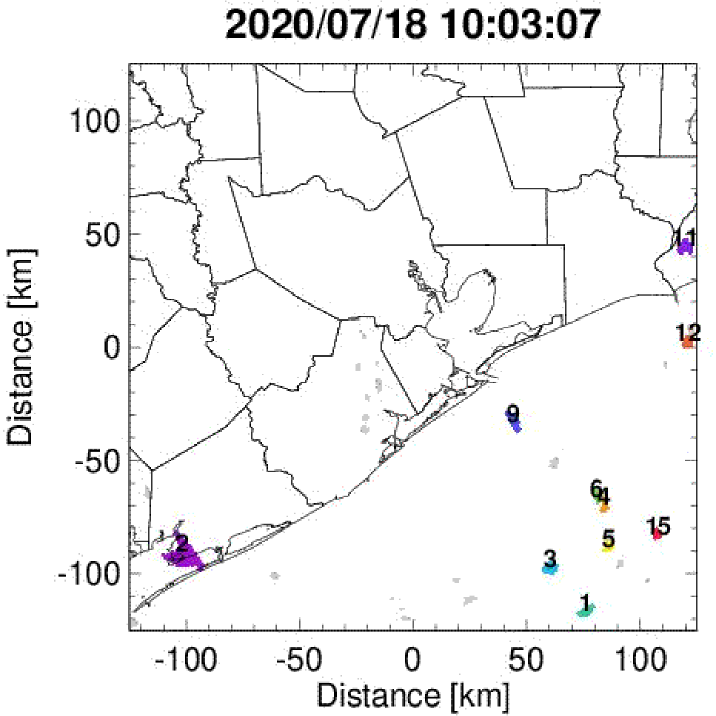
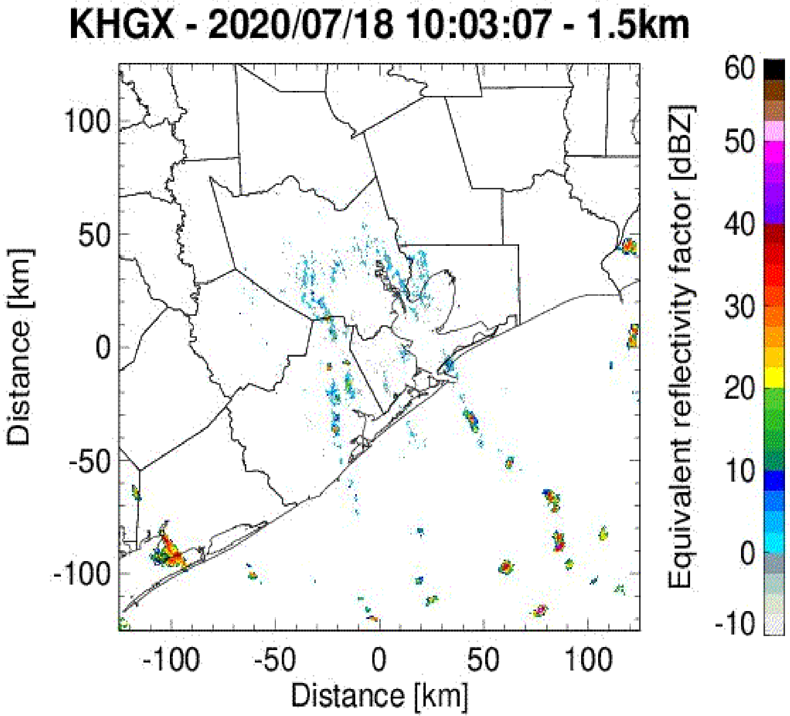
Kollias, et al., 2020: https://doi.org/10.1029/2020GL088440

Cell tracking is based on a modified version of the MCIT





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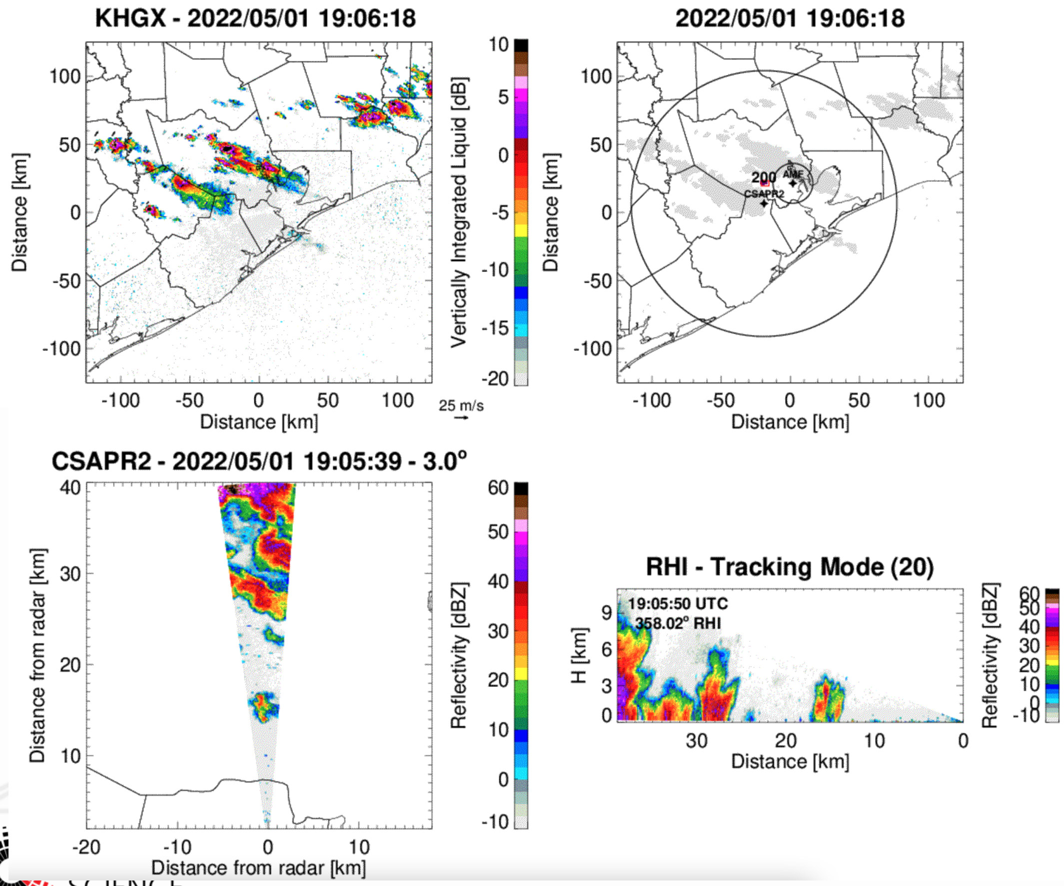
Cell tracking exampling CSAPR2



Track the lifecycle of convective cells with unprecedented temporal and spatial resolution using the Multisensor Agile Adaptive Sensing (MAAS) framework (Kollias et al. 2020)

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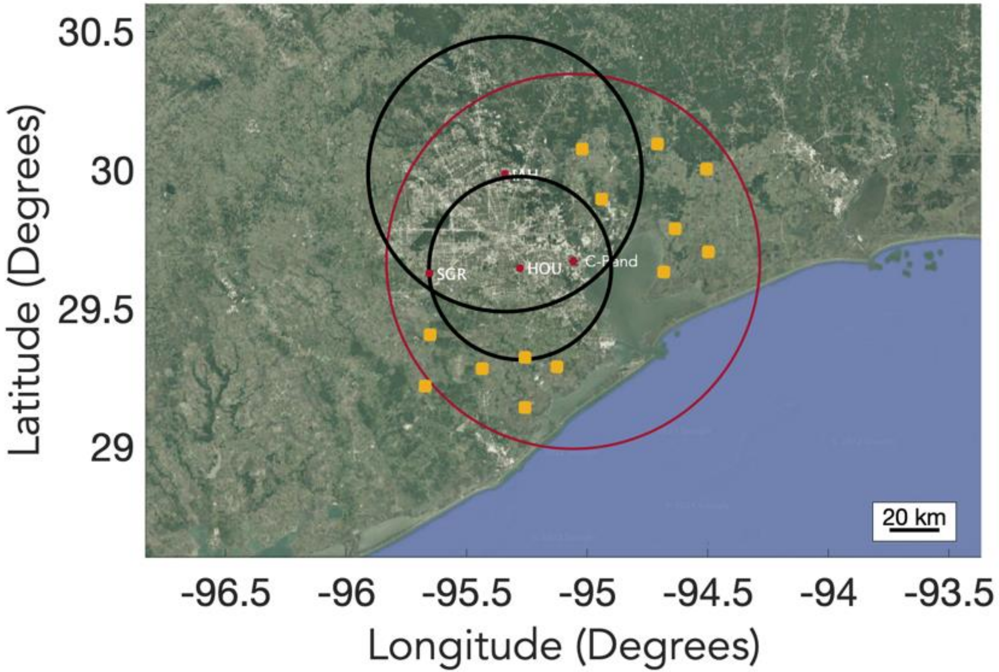
ESCAPE ground deployment sites

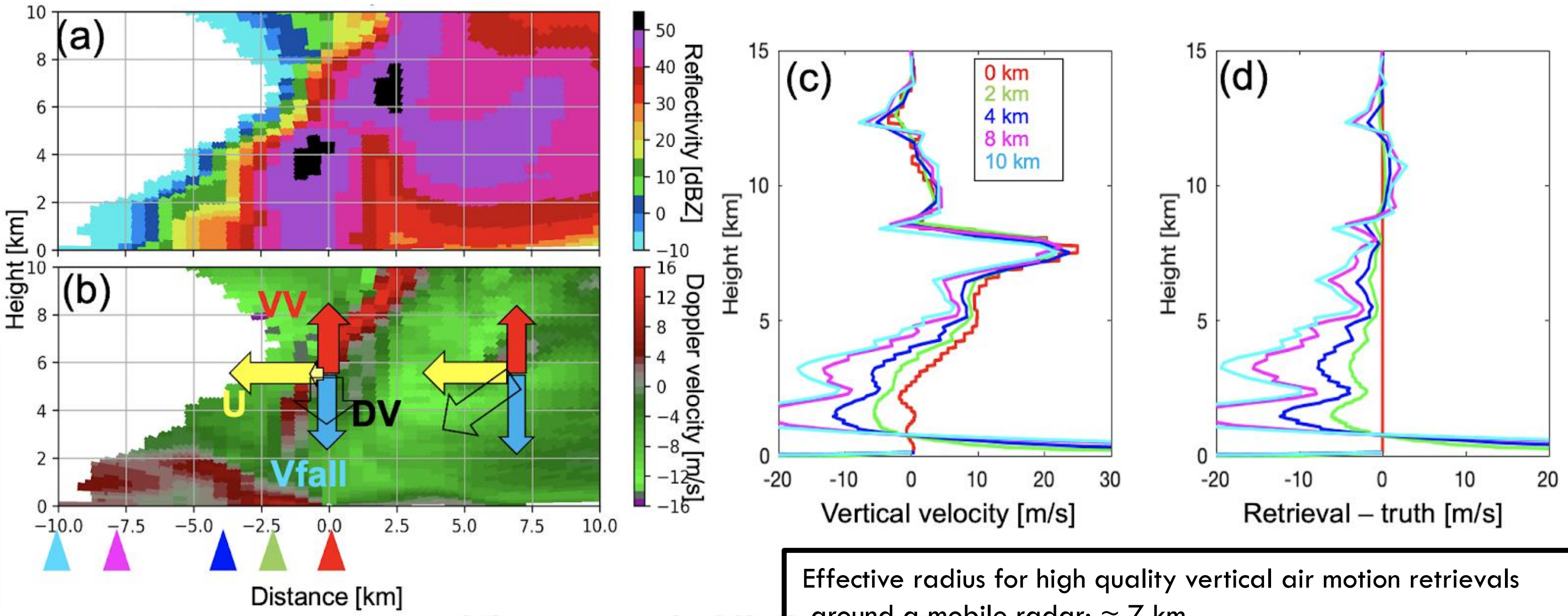
4 mobile trucks: one from Stony Brook University (SKYLER), one from BNL (CMAS), two from the University of Oklahoma (RaXPol and PX1000)



The trucks will deploy on the any of the yellow square locations.

Location	Mobile truck	Lat	Lon
South-East	RaXPol	29.630956	-94.683436
	PX1000	29.70528	-94.49785
	SKYLER	29.788332	-94.636331
East	RaXPol	30.074929	-95.020886
	PX1000	30.093188	-94.709965
	SKYLER	29.893634	-94.940551
	RaXPol	30.003162	-94.506881
South	RaXPol	29.290532	-95.125111
	SKYLER	29.142013	-95.259686
	PX1000	29.323730	-95.259644
South-West	RaxPol	29.283963	-95.436530
	PX1000	29.404636	-95.652665
	SKYLER	29.219124	-95.673864

Vertical air motion retrievals – Use of single RHI

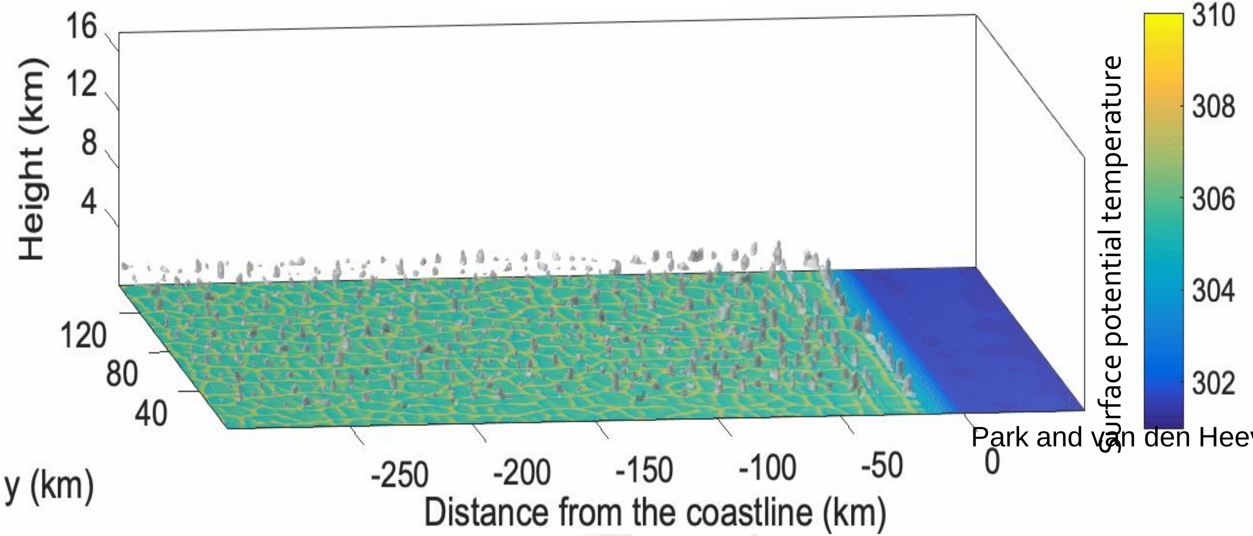


Oue et al., 2022

Effective radius for high quality vertical air motion retrievals around a mobile radar: ~ 7 km

Assumptions: Cloud top 12 km, minimum elevation: 60°

Cloud Resolving Modeling



Park and van den Heever 2020

Quantify environmental thermodynamic and kinematic controls on convective lifecycle properties under different aerosol conditions.

Quantify how cold pool properties and lifetimes vary as a function of precipitation amounts and precipitation size distributions, and how are these relationships modulated by (1) the relative humidity, (2) aerosol number concentration, and (3) land-surface types

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ESCAPE: Next steps

Feedback on the ESCAPE EOL field catalog (presentation by Peisang Tsai)

Identify real-time data streams

Operational products and imagery (e.g., NEXRAD, GOES, models)

Airborne instrumentation (presentation by Greg McFarquhar)

Coordination with DOE/TRACER (in communication with TRACER PI Michael Jensen)

C-band operations

Forecast

ESCAPE Contacts:

Lead PI and surface-operations: Pavlos Kollias

Airborne operations: Greg McFarquhar

Forecast lead: Eric Bruning, co-leads: Andrew Dzambo and Mariko Oue

Operations center: Peisang Tsai (NCAR)

Learjet: Paul Lawson

NRC Convair-580: Mengistu Wolde